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ABSTRACT

A modal approach is suggested for the selection of a microcomputer network that will identify specific needs and arrive at solutions with maximum flexibility to avoid technological obsolescence. Chapter 1 specifies functional needs for a network design. This chapter discusses the process of evaluating whether a network is appropriate; examines and specifies functional requirements; discusses physical, software, and procedural issues; and offers suggestions for projecting future needs. Chapter 2 addresses the methods of prioritizing and weighing functional needs, looking at why it is important to specify needs and allocate relative weights to those needs; and to identify trade-offs in such a way as to minimize potential network conflicts. Chapter 3 discusses basic alternative directions by explaining major Local Area Network (LAN) technical issues, i.e., network typologies; network access protocol; bandwidth; and transmission media; and summarizing the technological advantages of the issues presented, as well as current and future directions in network design; alternatives to universal design; and steps to a solution. Chapter 4 describes the final selection process, including a summary of the needs matrix and a discussion of case study selection. (HB)

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SELECTING MICROCOMPUTER NETWORK CONFIGURATIONS
- A MODEL FOR TECHNOLOGICAL ENDURANCE -

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Presentation at the 65th Annual Convention
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Microcomputer networks are becoming fairly common throughout higher education in both administrative and instructional settings. These networks are usually developed to satisfy a specific need such as office automation with file sharing within an office or building, or for instructional settings where a common software source will be shared.

Funding limitations dictate that these newly introduced networks will probably be around for a long time. Unfortunately, selection criteria for the networks is often limited to statements such as "It was the only one handled by our local vendor;" or, "a colleague spoke highly of this one."

In this paper, we attempt to establish a simple but workable approach to a process of network selection which will identify specific needs, and suggest solutions with maximum flexibility so as to avoid technological obsolescence in the short run. The specific topics covered are:

1. Specifying functional needs for a network design
2. Prioritizing and weighing functional needs
3. A look to the future - alternative directions
4. The network selection process

CHAPTER 1

SPECIFYING FUNCTIONAL NEEDS FOR A NETWORK DESIGN

EVALUATING WHETHER OR NOT A NETWORK IS APPROPRIATE

Although microcomputer networks are becoming fairly common, educators facing a decision about microcomputer configurations for instructional support or administrative purposes are often hesitant to get into networking, mainly due to "fear of the unknown" or confusion about which alternative solutions fit which specific sets of user requirements. The first evidence that something other than "stand-alone" configurations may be needed is usually the obvious redundancy of peripheral hardware necessary when a number of users of microcomputers occupy the same general work space. Each machine requires a printer, sometimes both a dot matrix and a daisy wheel type printer, each machine may require a hard disk, and several exotic devices such as plotters, optical readers, and color printers may be needed by one or more users.

Software usage patterns often provide another early symptom that something may be amiss. A classroom full of students learning a specific word processing package will require one copy of the software per student. Moreover, damage to diskettes and to disk drives resulting from the improper handling of diskettes by students may cause excessive machine down time. In another instance, several users who are working on a common document find it difficult to organize and merge text which was created on several independent machines.

Another indication of the need for a approach different from stand-alone computing arises from security related problems. Certain data needs to be protected from certain categories of user, and certain data must be guarded and properly backed up so that recovery is assured in case of accidental data loss or data loss related to equipment or power failure. Setting up procedures for a group of stand-alone microcomputers which are tight enough to preclude excessive risk of data loss is difficult if not impossible, and such procedures rely heavily on staff procedures which are especially vulnerable to turnover and absenteeism.

A more technically sophisticated category of need which might imply a network is that multiple microcomputer users may have a need to communicate with another micro, mini, or mainframe computer via a network (async, bisync, SNA, etc.) or via other carriers (telephone, private exchanges, etc.). In these cases, each microcomputer may be equipped to double as a terminal on an existing network and/or connected via modem to a external communications carrier, or the need may be addressed by establishing a microcomputer network and employing a gateway device approach.

The point at which a microcomputer network becomes cost-effective depends upon actual cost comparisons and the intrinsic value of being "technically correct". Actual cost comparisons are fairly easy to arrive at, less tangible aspects of environment such as the value of being "on the leading edge of technology" must be assessed or quantified by the person making the purchase decision.

EXAMINING AND SPECIFYING FUNCTIONAL REQUIREMENTS

The decision about whether or not a network is feasible should be based on factors such as those examined in the previous section. Total costs of peripherals (printers, hard disks, terminal emulation boards, modems, etc.) can be compared with various available network solutions, and when added to the less tangible costs (training time, probable storage medium problems, technological "profile", etc.) a fairly objective decision can be reached. Once this is done and if a network appears to provide a feasible solution, network planning should begin. Factors to be examined in the planning phase include:

PHYSICAL ISSUES	Physical layout of user stations
	Existing cable layout and adaptability to network
	Physical constraints to introduction of new cable
	Physical distance maximums
	Types of microcomputers to be included in network
	Types of peripherals to be included in network (specific)
SOFTWARE ISSUES	The specific application software to be used
	The nature of storage access requirements (read-only, I/O, multiple user file update, etc.)
	Security Requirements - Security levels (department, user, file, data element, etc.)
PROCEDURAL ISSUES	Amount of mass storage demanded by user and application
	Local (at work station) storage requirements
	Is stand-alone capability important?
	Boot (start) system via diskette or automatically?
	How many users (concurrent sessions) must access another network at one time?
	How many users (concurrent sessions) must be able to access public or private exchange (via modem) networks at one time?

These represent the majority of categories of information which you will need to begin network planning. For simple networks many of these categories will be "no response" or "no need". For more complex network requirements each of the items must be carefully assessed, with information gathered and assembled in some manner which allows for a comprehensive set of guidelines for decision making. One method of gathering data in a uniform manner is suggested later in the paper.

A DISCUSSION OF THE ISSUES

PHYSICAL ISSUES - The physical issues relate to the number of potential network users, the types of devices intended for inclusion in the network, and the layout of the facility(s) in which the network is to be located.

All networks have a physical limitation on the number of member stations which can reside on the network. This number ranges from as few as six to hundreds of member stations. The fact that a certain network boasts a high number of potential member stations may be less important than performance specifications which will indicate how well the network performs under certain types of workloads. There are a number of sources for information on performance, and general guidelines are offered in this paper. Perhaps the best guide to network performance is to talk to the users of an existing network which is used for a purpose similar to the one planned for the network under consideration.

Cabling requirements are always a difficult consideration when planning a network. Certain networks require coaxial cable of specific ohm rating, while others require twisted pair cable which is the same (two or four wire) as the cable used for the standard telephone system. In some cases existing twisted pair cable may be usable for a new network, but distance constraints and switching connections usually mandate that new cable is strung. Stringing cable is expensive, especially because building codes and appearance are key elements in the design. The best solution is to plan for all near term (2-5 year) communications needs and then try to select a network which uses cable that can support all of the identified communications needs. This reduces future costs, but fitting all needs into one cable characteristic is difficult with current technology. Fiber optics promise to solve the difficulty, and when combined with digital switching PABX units this technology promises true universality. There are solutions which when combined with adequate planning will provide maximum future flexibility through layered network typology.

The constraint of distance is often a limiting factor when planning cable layouts. The most common networks have distance limits of less than 1/2 mile. Some networks have signal boosters which can increase the distance limit, but excessive distance brings other inherent problems such as vulnerability to noise.

A determination must be made regarding the types of computers, peripheral devices, and external communications accesses that will be included within the network. Each different type of computer which is to be connected to the network may require a different network protocol board. It is important to ascertain which computers a certain network manufacturer supports, and which it plans to support. The larger, more stable network

manufacturers can be counted on to support a wider range of computers and devices than the newer smaller manufacturers. In addition, the product lime directions which are already supported by a manufacturer will give the buyer a clue as to future direction. Additionally, the operating system software which the network supports will dictate which mass storage devices will work with the network, and how easily the network may support multi-user applications. These specific technical issues will be dealt with in detail later in the paper.

SOFTWARE ISSUES - It is important to plan in advance which applications software you expect to use with the network for several reasons. First, depending upon which operating system the network uses your choice of software for a certain application may be limited. Secondly, some software vendors will negotiate network discounts which are very beneficial when compared to stand alone software prices while others will require a license fee for every station on the network.

Perhaps of greater importance is the nature of the intended application. If multi-user access to data is intended (more than one user reading and writing to a data set at one time) it is important to select a network which supports software designed for that purpose. Some software utilizes "file locking" which means that only one user can access a file at a time, while some utilizes record locking, some utilizes data element locking, and some offers no locking capability at all. The type selected will depend upon how many users will be accessing which class or classes of data simultaneously. For instance, if a warehousing application is planned, in which a number of users will be updating incoming and outgoing material at the same time, file locking would be prohibitively slow, and record or data element locking, or some other scheme of insuring accurate updating would be called for. For an application in which an individual record may be updated by a number of users (name change, charges, etc.) it is less likely that two users would be updating the same record at the same time, so record locking might be appropriate. In yet another instance, a group of word processing operators may have work assigned in a way which precludes two or more of them working on one document at the same time, so file locking would be satisfactory for the application. Security requirements are as complex as data sharing considerations, and must be analyzed with similar care. Clear definition of the data requirements in the planning stage will preclude selection of a network which cannot support the intended application(s).

PROCEDURAL ISSUES - Exactly how the network will be used involves analyzing several procedural issues. Networks usually require that a member station identify itself as active to the network host (often called server). This is usually done by starting the member station with a program which is stored on a diskette supplied by the network vendor (called a "bootstrap" or "boot" diskette). For instructional and some administrative

applications this will prove cumbersome, because the boot diskettes must be used each time a station is turned on or off, and students may lose or damage the diskettes. Many networks offer solid state option chips which replace the boot diskette, and start the member stations automatically when the power is turned on.

It is also of importance to determine how often if at all the members will be used as independent computers which are not part of the network. How difficult it is to use the computer without network services should be assessed, and a close look at the quality of the documentation which explains how all of this is accomplished by the user will help in the network choice.

Another software/hardware consideration is the extent to which users will require access to another computer network (usually a mainframe host network) or an external communications device such as a modem. Some networks allow several or all users to access a single gateway for communications purposes, while others do not. It is also important to determine what additional hardware and/or software will be necessary to make member stations behave like certain computer terminals (VT 100, 3278-9, etc.), and whether or not the hardware board if required is compatible with the network board in the same member station. Pay close attention to the specification of ALL characteristic physical, software, and procedural issues when planning a network. The method of linking the identified characteristics to a single or narrow choice of networks will be the subject of chapter five.

LOOKING AHEAD TO FUTURE NEEDS

The near future (1-3 years) will surely bring some changes in your needs, and some rather dramatic changes in the technology and price of networks. Making a move today need not lock out the possibility of taking advantage of the future offerings, but care should be taken to look ahead and plan a network with future flexibility in mind.

Simple networks which are designed for a single purpose (CAD/CAM instruction for example) may be based on a fixed set of peripheral devices and a fixed set of software which you feel will not change during the useful life of the network. In addition, you may be fairly certain that another set of users will not want to share in the use of the network in the future. These sort of givens make planning for future changes a minimal problem. For most networks being planned however, future needs in terms of peripheral devices to be added or software demands are not well defined. In these cases it is possible to at least establish probable direction, and that will allow the planner to accommodate some of the probable demands of the future.

The more critical future needs which can be assessed to a degree in advance include:

What is the upper limit of the number users who would logically (from a standpoint of data sharing and physical location) be added to the network?

What new applications might be added to the network?

How much physical device flexibility will be necessary?

What future communications requirements might be placed on the network?

Answers to these questions will help in the determination of a network configuration. Naturally, there is a positive relationship between the flexibility and upwards compatibility of a network and network cost, but the factors of cost and flexibility should be balanced to accommodate the specific installation to the highest degree possible.

CHAPTER 2

PRIORITIZING AND WEIGHING FUNCTIONAL NEEDS

WHY IT IS IMPORTANT TO SPECIFY NEEDS AND ALLOCATE RELATIVE WEIGHTS TO THOSE NEEDS

The section dealing with functional requirements listed most of the needs typical of a network which would be used for instructional or administrative purposes. You will find that some of your needs are clear and definite, and others are less well defined. Some criteria may be of utmost importance while others could be classified as "nice to have if possible." At the end of the network definition process the requirements/needs will have to summarized and evaluated in a way which will denote which specific network solutions will be the most effective. To accomplish this to a satisfactory degree of precision it is necessary to apply weights to the requirements/needs.

IDENTIFYING TRADE-OFFS, MINIMIZING POTENTIAL NETWORK CONFLICTS

The purpose of the process being suggested in this paper is to guide the network planner through the steps of requirement analysis and network selection in a way that will preclude the planner from ending up with a network that cannot satisfy the intended purpose, or from spending unnecessary amounts of money for a network which has features and flexibilities which are not required.

Network conflicts are most likely to result from situations such as:

Network size far exceeding the original plan
A requirement to connect a non-compatible device to a network (a new type of laser printer, etc.)
A need to tie a LAN into an existing or a new mini or mainframe computer network
A need to provide file sharing with some new software
A need to connect services (electronic mail, etc.) between two networks of different manufacture

Some future requirements/needs cannot be foreseen, but awareness of the potential problem areas, and a process of involving key users with network planning can prevent the installation of an inadequate network which must be totally replaced at a later date. In order to deal with the magnitude of issues surrounding a network decision, it is suggested that you begin by establishing a simple two-dimensional matrix with the requirements/needs on one axis and the relative weights along the other. The following matrix is an example of an actual network matrix for an instructional application which was intended to serve an accounting lab of approximately 40 students.

	ISSUE	DESCRIPTION	RESOLUTION REQUIRED?	PRIORITY
PHYSICAL ISSUES	PHYSICAL LAYOUT	Does the planned network's layout favor any network type?	N	-
	EXISTING CABLE	Is there existing cable which could be used for the network?	N	-
	PHYSICAL CONSTRAINTS	Are there physical constraints which prevent use of any specific cable?	N	-
	PHYSICAL DISTANCE	Does the distance to be covered by the network prevent use of any specific network?	N	-
	TYPES OF MICROCOMPUTERS	IBM PC compatible and DEC and XEROX	Y	1
	TYPES OF PERIPHERALS	Must have print spooler and support XEROX laser printers (or equivalent)	Y	1
SOFTWARE ISSUES	APPLICATION SOFTWARE	Must support MS-DOS	Y	1
	STORAGE ACCESS	Requirement for Read-only	N	-
	SECURITY REQUIREMENTS	Must have password facility and have file level access security	Y	1
PROCEDURAL ISSUES	MASS STORAGE	10 MB initial - expandable to 100 MB	Y	2
	LOCAL STORAGE	At least 360 KB floppy	Y	1
	STAND-ALONE	Must function as stand-alone unit and run different operating systems without physically detachment from network	Y	1
	BOOT OFF ROM	Must be able to boot with-using a boot diskette at workstations	Y	1
	CONCURRENT NETWORK USERS	Must allow 40 concurrent users to access bysync network in 3278 look-alike	Y	1

DISCUSSION OF THE MATRIX - The matrix illustrated here is meant to guide the network planner through the process of identifying the issues which will require resolution during the process of selecting the specific network to be acquired. The issues listed are the most common ones encountered, although additional issues may become important for more complex networks. The issues are really the operational specifications for the network in graphic form. The resolution of the issues will involve matching each of the issues for resolution with a particular type of network, thus following a process of elimination. The magnitude of priority is to soften the process, in cases where every network type is being eliminated, or cost limitations must mitigate the resolution process.

The network being specified in the matrix is a simple, one dimensional network (from a standpoint of usage characteristics) which will be used for instructional purposes only. It is intended primarily for use in an EDP/accounting laboratory, and must run software for accounting case studies, word processing (specifically Display Write II and WordStar), Basic, Pascal, Fortran, Cobol, and each workstation must double as an IBM 3278 terminal for use with an IBM mainframe computer using a bysyncronous network. No cable exists in the room now, and the only constraint is that it must be easy to add units to the cabling once it is installed.

It is very important that students be able to start the workstation without a boot diskette, because the lab will not be staffed at all hours and the boot diskettes would not always be available. Students will keep their own work on floppy disks so each unit must have a disk drive. At times UNIX will be used on individual machines, so it must be easy to use the work station as a stand-alone computer without having to disconnect the unit physically from the network. Passwords will be assigned, and security must be offered at the file level, especially since some faculty will use the network and mass storage unit for their personal workfiles.

Computers to be initially used on the network include IBM PC/ATs, IBM PC and PC XTs, DEC Rainbow and Rainbow 100, and the XEROX personal computer. A central high speed dot matrix line printer will be used with a print spooler, and a laser printer will be added as a network addressable station for special output.

In order to match the issues for resolution with the appropriate network it is necessary to know about network characteristics in general, and then to know about specific manufacturer's networks which fit within the general characteristics. Chapters 3 provides general information about network characteristics. Chapter 4 will focus on the process of making the final network selection decision.

CHAPTER 3

THE BASIC ALTERNATIVE DIRECTIONS

BASIC NETWORK TECHNICAL ISSUES

When reading about microcomputer networks or dealing with vendors the same buzz words keep coming up over and over again to describe the network and how it works. Local Area Networks (LANs) provide by definition a distributed control strategy for the various member stations in the network. Distributed control means that each member station can independently establish access to the network by an accepted set of rules. This is opposed to centralized control in which access to the network is controlled by one member or master station. A very common LAN is called Ethernet. It is described as being a bus based, contention access, baseband LAN implemented using coaxial cable. The purpose of this chapter is to clarify what this all means and establish the basic advantages and disadvantages associated with the major LAN technical issues.

NETWORK TOPOLOGIES

A network topology is the arrangement of the physical communication paths between the member stations of the network. Any topology can be created by using a series of point-to-point connections where only two member stations are linked to each other by a single line or a multipoint arrangement where many member stations share a single line. The most common topologies used by LANs today are either ring or bus in nature.

A ring topology is a point-to-point arrangement of member stations such that an unbroken circular loop or daisychain of stations exist. Each station must be able to recognize its own address so it knows if a message is meant for it or for some other station. If a message does not belong to a station it must also be able to repeat the message t the next member station in the chain. Ring networks are attractive because of their simplicity and ease of growth. The major disadvantage of a ring network is its reliability. The malfunction of a member station will bring the entire network down, therefore it is usually necessary to provide some sort of bypass capability into the network which can tend to negate some of its advantages.

A bus topology is a multipoint arrangement of member stations. Each of the stations is connected to a single physical cable via taps or connectors. Each member station must also be able to recognize its own address but does not need the ability to repeat a message that it receives because every station is connected directly to the same physical channel. This type of topology is very resistant to any single failure of a member station because each individual station is tapped into the bus and all stations can receive the same message at the same time. The bus structure

is also very flexible allowing easy addition of stations or moving of stations in the network. The only disadvantage is in the greater difficulty in locating and isolating network problems.

NETWORK ACCESS PROTOCOL

Network access protocol describes the manner in which the member stations in a network can gain access to the network channel in order to communicate with other stations. It can be thought of as the Roberts Rules of Order of the network world or just simply traffic control. The two major access methods commonly used by LANs are token passing and contention strategies.

Token passing is a method in which a special message (the token) constantly circles the network from station to station indicating that the communications channel is clear. To send a message, the member station must grab the token and transmit the data it wants to send. No other station can send a message unless it has possession of the token. Once the station with the token has transmitted and verified its message was received or a certain amount of time has passed the station puts the token back in circulation. In this way network traffic is controlled because only one member station can talk at a time. Token passing can be used on both ring and bus network topologies. Using this access method it is very easy to expand the number of member stations in the network without serious performance problems. The time it takes for a message to navigate the network can be quite predictable making this method useful for real time applications. The major disadvantage is that care must be taken that the token does not get lost. Various schemes to do this can add an extra layer of complexity to the network.

The most common contention strategy is carrier sense multiple access collision detect (CSMA/CD). This method relies on each station that wishes to transmit a message to first listen to the channel to see if it is clear. If the line is clear a station will proceed to transmit its message and then listen to the message it just sent. If two stations attempt to transmit at about the same time they will detect a garbled message (a collision). The affected stations will cut short their transmissions and wait a random period of time before attempting retransmission. This technique is used exclusively on bus topologies. Contention is a simpler strategy to implement and thus also provides greater flexibility. The major disadvantage is that as more member station are linked into the network the chance of transmission collision will rise, and the more collisions that occur the more the network performance degrades. This is why you will find many contention systems implemented on a transmission media with very high transmission rates to help avoid this problem.

BANDWIDTH

The term bandwidth is used to describe the networks ability to move data between member stations as well as the range of analog signals that can be carried by a physical medium. Most of the current LANs on the market transmit their data using a baseband or a broadband technique.

Baseband transmission is where data is sent at its original frequency. The transmission can be either digital (on or off signal) or analog (continuous wavelike signals). The transmission of data uses up the entire data channel much like water in a hose. Data can be sent up to the full capacity of the physical transmission media being used, and only one type of message can be sent at a time. This is a very simple, fast and inexpensive form of transmission. It can however do only one thing at a time, and therefore creates a problem if you would like to send data and voice over your network at the same time over a single physical line.

Broadband transmission is where many different types of signals are sent over a physical medium at the same time. The capacity of the transmission media being used is broken into many different logical channels so data, voice, TV and other signals can be all sent together at the same time. Broadband is an analog form of communication where each message group is sent at a different frequency much like having a multi-lane freeway with each lane with a specific designation. Using the freeway analogy we would have one lane reserved for buses, another for trucks, and still another for cars. If the freeway needs to go both to and from the city, we would have six lanes, one for each vehicle type going to the city, and one for each vehicle type going away from the city. Because the traffic is broken up into many small designated lanes we can not get quite as many cars through in a particular time frame as if we were to use all six lanes just for cars. The added service diversity provided by a broadband LAN comes at a substantial increase of cost and complexity.

TRANSMISSION MEDIA

Transmission Media is the physical channel used to interconnect member stations in a network. Most LANs in use are designed to communicate over twisted pair wire or coaxial cable. The geographical limitations found on LANs are most often the result of the transmission media selected.

Twisted pair wire is the wire type most often found and is used in telephone communications. The wire is usually made of copper and are twisted together into wire pairs to help reduce electrical interference. Twisted pair wiring is used for low speed transmission. Transmission speeds can be as high a 10 million bits per second (Mbps) but most current LANs transmit at speeds of 1 Mbps or less. Twisted pair is relatively low in cost

and is typically pre-installed in office buildings. It is the most cost effective choice for single building, low traffic requirements. The major disadvantages of using twisted pair is that is is very prone to electrical interference from adjacent wires and from external sources such as fluorescent lighting and heavy electrical loads, and is also limited to low baseband transmission speeds.

Coaxial cable is the main form of media used by the cable TV industry and is also used by the telephone industry primarily for long distance calls. Coaxial cable consists of a central carrier wire, insulation and an outer mesh. It can accommodate either baseband or broadband transmission. Data transmission speeds of 20 to 50 Mbps can be achieved, with most LANs typically in the range of one to 10 Mbps. Coaxial cable is fairly resistant to outside electrical interference thus having a low error rate. Many type of taps, connectors and repeaters are available which makes it very easy to branch or extend the cable to interconnect work stations. Coaxial cable has become the most common transmission media for LANs because of its large capacity, low error rate and flexibility. It is well suited for both indoor and outdoor environments, therefore inter-building and even intra-campus networks can be supported. The major disadvantages are that it is much more expensive than twisted pair and is often difficult to wire an already existing building with cable.

SUMMARY OF TECHNICAL ADVANTAGES

There are trade offs for each of the major technical issues presented. Other technical issues such as ease of installation, ease of use, file access capabilities, network security, and limitations on number of work stations, peripherals and users are currently vendor dependent. The following represents a summary of the major LAN technical issues:

ISSUE	CHOICE	COST	FLEXIBILITY	CAPACITY	GROWTH
Topology	Ring				X
	Bus	X	X	X	
Protocol	Token			X	X
	Collision	X	X		
Bandwidth	Baseband	X	X		
	Broadband			X	X
Media	Twisted pair	X			
	Coaxial cable		X	X	X

[This table adapted from Communications and Networking for the IBM PC by Larry E. Jordan and Bruce Churchill, Robert J. Brady Company, 1983, page 118.]

CURRENT DIRECTIONS OF NETWORK DESIGN

The microcomputer industry has a history of standardization through commercial dominance. It is therefore important to assess where the industry currently is in terms of microcomputer networking before we look to the near future. If we want to get the most for the money that we invest, it is important to ave the maximum flexibility in the different types of hardware and software which we can use both now and in the future. Investing in a network architecture that is 'state of the art' can be a dead end if there is litt! in the way of software to use, compatible hardware or peripherals available.

Currently the de facto microcomputer standard is the IBM Personal Computer and its compatibles. The majority of application software that is available is now being developed to run under Microsofts MS-DOS operating system. In the area of educational software, Apple DOS is still the leader but is being rapidly overtaken by MS-DOS applications. Local Area Networks are the primary means being used to network microcomputers. Of all the different types of LANs being used, baseband, bus based contention systems are the most common. The promotion of Ethernet by Xerox, AT&T and DEC and its issue of Ethernet licenses to over 200 other companies is a significant factor in the battle for the LAN marketplace. It seems to be a toss up on the use of twisted pair wire verses coaxial cable, but coaxial based broadband systems are beginning to gain momentum. The most recent announcement of IBMs new PC network, a broadband, bus based, contention system using coaxial cable, reinforces the current trends in microcomputer LANs.

It might seem that the current trends in microcomputer networking give us a good indication on which way to proceed in our network selection to achieve the most flexible and durable result. Unfortunately, this is not the case. Each vendor's network hardware and software is generally incompatible with what the other vendors have to offer.

FUTURE DIRECTIONS OF NETWORK DESIGN

There are currently a number of official bodies looking at standards issues regarding networks but it seems unlikely that any one standard will be adopted universally. The IEEE Standards Project 802 was established by the IEEE Computer Society to look into this issue and ended up recommending three different standards. A bus based contention system (CSMA/CD) using either baseband or broadband coaxial cable (IEEE Standard 802.3); A bus based token passing system using either baseband or broadband coaxial cable (IEEE Standard 802.4); and lastly a ring based token passing system using baseband twisted pair wire or baseband coaxial cable (IEEE Standard 802.5. To make issues more complicated, future trends will give rise to more options.

The future trends in microcomputer technology will possibly give rise to the 32 bit UNIX based work station. UNIX is a computer operating system developed at Bell Laboratories, and offers power and flexibility for multiuser network environments. In the area of microcomputer networks there should be a trend towards more centralized network strategies through more microcomputer work stations being used on mainframe computers (i.e. IBMs 3270 PC) as well as the rise of the Digital Private Automatic Branch Exchange (PABX or CBX). Optical fiber promises to be a major supplement to both twisted pair and coaxial cable private networks in the decade ahead.

Digital PABX or CBX units are in essence centralized digital switching devices intended to handle a wide variety of local networking requirements including voice and data transmission. It is typically limited to 56 kb transmission rates, which limits the number of users which can be supported on one channel at decent response rates. This speed (using twisted pair cable) will be increased to 256 kb or higher in the next few years which will make the technology much more appealing for office automation and local area network applications.

Optical fiber technology uses fibers of plastic or glass and offers tremendous transmission speed and little vulnerability to interference. Splicing and connecting devices to optical fiber is very expensive today, but the costs are expected to become reasonable and competitive in the near future. When coupled with the PABX or CBX technology, optical fiber will likely open new alternatives for networking technology with a wide dispersion of applications and cost effective solutions.

BRIDGES AND GATEWAYS - ALTERNATIVES TO UNIVERSAL DESIGN

As we can see the issues and choices surrounding the networking of microcomputers will become more and more complex. It seems that no matter what we do our network will not be able to be all things to all people or provide adequate flexibility to take advantage of new technology. Internetworking through the use of gateways can offer a solution to the problems caused by conflicting functional network needs. In many cases an organization may have more than one type of network at a given site to satisfy a variety of needs. The organization may also have networks at various sights and may need them to be interconnected for information exchange or central control. There may also be a need to connect to other outside computer resources.

THE BRIDGE - The simplest kind of connection between networks is called a bridge. A bridge is used to connect two similar networks so they may communicate to each other. An example of this would be where two separate Ethernet networks are connected together.

THE GATEWAY - The gateway provides a solution for the more difficult problem of connecting dissimilar networks together. The term internetworking is used to describe this situation. The gateway provides any type of protocol conversion that is necessary for the two networks to communicate. The most common types of gateways found for microcomputer networks allow you to use the micro as a terminal tied to an external network or to a mainframe computer. Because "universal gateways" are impractical due to the different message sending protocols used by unique manufacturers it is very important that you determine whether or not a gateway exists to connect the two or more networks with which you plan to work. Future product announcements are fairly reliable from some vendors, but must be viewed with extreme caution if the connection is to be a critical requirement for the network. Enough gateways exist on the marketplace today to provide a decent range of choice during the selection process.

STEPS TO A SOLUTION

So far the paper has detailed the areas of concern when establishing specifications, and suggested a general process for quantifying the overall specification in a simple matrix. General network characteristics were then discussed, so that a framework could be developed for matching the identified specifications with available technology. The next steps are to detail and refine the selection process so that a final decision can be made. The specific final steps are:

1) Carefully define current and future network functional requirements (prepare the matrix for your network)

2) Define the current and possible future relationship between the network being developed and other networks

3) Select the general network model (bus contention, token passing, broadband, etc.) which best fits the greatest number of functional needs and concurrently provides the maximum flexibility for a variety of peripheral equipment and software

4) Study each vendor's offerings of the network model type which you have selected. Don't confuse the issue by considering network types outside of the general network model which the process has led you to.

5) Match the final selection with a bridge or gateway if communication with another network was specified. Be sure to ascertain whether transmission speed limits are adequate to insure that a communications bottleneck does not defeat the purpose of the design.

Chapter 4 presents an overview of the selection process which was used for the network specified earlier in the paper.

CHAPTER 4

THE FINAL SELECTION PROCESS

SUMMARIZING THE NEEDS MATRIX

The final goal of the selection process is to match a specific network configuration with the needs which you have specified for the application(s) under study. Further, the intent of this paper is to couple this selection with a look to the future in a way which will give you the greatest probability of future endurance and flexibility. The suggested approach to accomplish these goals, satisfying current needs and providing for technological endurance, is to develop a summary statement describing the proposed network and then to match this statement with a network standard (IEEE 802.2 plus 802.3 or 802.4). In addition, it is suggested that the selection be tempered with an analysis of the existence, or the probability of the existence of a suitable gateway device so that the selected network will be able to link to other networks in the future.

To develop a network summary statement, you should refer to the needs matrix on page 8. Some of the issues in this matrix will influence selection of a specific type of network, other of the issues will influence the selection of a specific manufacturer's network over another **WITHIN** the specific type of network. The issues which are primary determinates of the type of network are:

PHYSICAL - Existing cable; types of microcomputers, types of peripherals

SOFTWARE - Type of access requirements (when coupled with number of concurrent users indicates speed reqmts)

PROCEDURAL - Mass storage, concurrent users

FUTURE - Growth capability, future hardware flexibility

OTHER - Cost, limits to amount of facilities change you are willing to incur (mainly wiring considerations)

Issues which will influence your selection of a specific vendor's network within a network type are cost, features and quality of available network software, flexibility, stand-alone and boot-off-rom mechanics, and the stability and probable future of the vendor, especially regarding the availability of gateways.

Using information gathered from your network needs evaluation matrix, look to the issues listed above and prepare a descriptive paragraph which includes the key determining issues. The following descriptive statements and the selection which follows will serve as a guide for this final selection process.

SUMMARY STATEMENT	NETWORK TYPE					
	BUS CSMA/CD non-std	IEEE 802.3 Base-Band	IEEE 802.3 Broad-Band	IEEE 802.4 Base-Band	IEEE 802.4 Broad-Band	IEEE 802.5
Limited size and scope, defined hardware, no growth, >20 stations, cost limitations	X	X				
Small size (>41), future hardware flexibility important, speed important, growth possible		X	X			
Same as above but with possibility of shared wiring (voice or CATV)			X			
Medium - large size (up to 250) with large capacity, future hardware flexibility, some growth capacity				X		
Same as above but with possibility of shared wiring (voice or CATV)					X	
Medium - large size (over 1,000) with great expansion capability and future hardware flexibility						X

The example being used in this paper which is the subject of the evaluation matrix on page 8 could be summarized as a network which is small in size (>41), requires current and future hardware flexibility, with speed being an important criteria, with some growth capabilities (statement 2 above). This summary statement indicates that the appropriate network type(s) for consideration would be either baseband or broadband CSMA/CD (IEEE 802.3). Once this distinction is made, the process of selecting a specific network within this category will depend upon the remaining issues outlined in the evaluation matrix.

The statement made by this final selection matrix is that in taking a close look at the current and future needs that are to be fulfilled by the network being planned, the planner should be able to arrive at a network type which generally provides a "best fit" for these needs. Further, it is suggested that a specific

IEEE standard be adhered to in an attempt to insure future technological endurance. While some planners claim that gateways obviate the need for supporting evolving standards, it is strongly suggested that the availability or possible availability of gateways be used to hedge the bet for future flexibility rather than to guarantee it. An excellent example of this is implicit in IBM's marketing of the new CSMA/CD LAN(802.3) while announcing the IBM wiring scheme and lobbying for IEEE's 802.5 standard to be descriptive of their token ring plan. The CSMA/CD LAN will be available early in 1985, and will probably comply with IEEE 802.2 and 802.3. IBM seems to be betting that broadband LAN's will solve the immediate need for high speed, small networks, while the later more comprehensive solution (802.5) will probably be to tie the LAN's together with other networks in the token-ring approach, with each individual LAN being treated as a single recipient of the token for transmission purposes. If this is the direction, the token-ring network (ROLM CBX?) would act as a general gateway for the LAN Ethernets which will be widespread by the time the token-ring typology is marketed.

This speculation is important only in that it illustrates a main point of this paper, which is that the planner must select a network type which can accommodate the immediate needs which are identified, comply with IEEE standards for future endurance, and finally do a bit of guessing about a manufacturer's intentions if the best selection is to be made. Following this approach, even if the crystal ball gazing about a particular manufacturer fails, the adherence to standards will assure a decent future with a good return-on-investment for the selected network.

THE CASE STUDY SELECTION

After determining that the most appropriate network type would be an ethernet, and that the ethernet should conform to IEEE 802.2 and 802.3, while satisfying the greatest number of specified hardware, software, and procedural needs, the 3Com Ethernet hardware and software was selected. This particular equipment descends from the Xerox Corporations ethernet development history, and much of the technology is cross-licensed with Xerox and is compatible with Xerox's direction thus far, and supports the various hardware and peripheral devices specified in the requirements matrix. Further, the software supports all of the functions specified, and the procedural issue of "boot off ROM" is supported. Total conformity to IEEE 802.2 and 802.3 was not present at the time of the selection, but the "majority" of standards issues were complied with and 3Com claims intentions to completely conform in 1985. These facts, when compared to the other available network choices at the time of the decision (late 1983) made the selection of this specific network favorable, and the realities of installation and operation have verified, or at least not invalidated the selection. It should be noted that other vendors (notably Ungermann-Bass) have been aggressively

pursuing ethernet products which conform to standards yet retain some degree of product differentiation for the marketplace. This tendency leads to "nearly standards compatible" networks which require gateways or bridges to communicate with other networks, and while this is not ideal for the consumer, it is bringing the ethernet world nearer to interchangability. Network manufacturers prefer to refer to the International Standards Organization's Open Systems Interconnection model (ISO's OSI Model) because this allows the manufacturer to pick and choose a set of network layers, which when combined conform to the model. This tendency is not creating solid communications compatible design, and is likely to be replaced with more specific top to bottom standards specifications when ISO accepts the IEEE standards (802.2 and 802.3 are complete, 802.4 is nearly settled, and 802.5 is evolving).

The model for network selection proposed in this paper is a process which will help guide the network planner through the requirements specification process, and later to match the determined requirements with a specific network type. The final step then is to determine which manufacturer's network will best fit the determined needs within the network type. It is up to the planner to keep updated on marketplace offerings, and most certainly to force standards conformance by selecting only those products which most closely conform to standards as these standards evolve.

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